

DELINEATION AND MAPPING OF SOIL AVAILABLE ZINC AND BORON STATUS IN SOILS OF SALEM DISTRICT OF TAMIL NADU

RESHMA M. R, V. P. DURAISAMI, D. MUTHUMANICKAM,
SONIYA PURMA & N. JAYASOORIAN

Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University,
Coimbatore, Tamil Nadu, India

ABSTRACT

The study was conducted in soils of Salem district of Tamil Nadu to delineate the soil available zinc and boron status. Totally 1691 soil samples were collected @ 4 samples per village covering 385 panchayat villages in 20 blocks of Salem district. Samples were collected randomly at 0-15 cm depth and the GPS data (Latitude °N and Longitude °E) were recorded from each sampling site. Soil samples were analyzed for DTPA-Zn (Di-ethylene Tri-amine Penta Acetic acid extractable Zinc) and HWS-B (Hot Water Soluble Boron). The analytical results were used for calculating per cent deficiency, nutrient index values and fertility ratings. The thematic maps were generated to show the extent of micronutrients deficiency or sufficiency based on block mean, nutrient index values and spatial variability. Zinc deficiency was noticed in all the blocks which demand suitable management strategies for Zn nutrition of crops. Next to Zn, B deficiency was evidenced in all the blocks except Attur, Gangavalli, Mecheri, Omalur and Valapady. A totally 32.3 per cent of the samples were found to be B deficient. The fertility rating class for Zn is marginal (1.75) whereas B (2.01) is adequate.

KEYWORDS: Di-Ethylene Tri-Amine Penta Acetic Acid (DTPA), Hot Water Soluble (HWS), Nutrient Index Values, Fertility Ratings and Thematic Maps

Received: Dec 09, 2015; **Accepted:** Dec 24, 2015; **Published:** Dec 29, 2015; **Paper Id.:** IJASRFEB20168

INTRODUCTION

Micronutrients fertilization is as important as macronutrient fertilization even though it is required in less quantity. The deficiency of micronutrients leads to plant abnormalities, reduced growth and lower yield. Deficiency of micronutrients in soils and plants is a global nutritional problem and is prevalent in many countries with variation in magnitude of severity. Deficiency of micronutrients has grown in both, magnitude and extent due to increased use of high analysis fertilizers, adoption of high yielding crop varieties and increased cropping intensity. The deficiency may either be primarily due to their low contents or secondarily by soil factor that reduce the availability (Sharma and Chaudhary, 2007). Deficiency of Zn covers the largest area in India and deficiency of B is common in coarse textured, low organic matter soils occurring in high rainfall regions.

In the present era of precision farming, the inputs are applied as per the location specific requirements of the crop. Systematic collection of georeferenced samples and preparation of spatial data for the distribution of nutrients is possible using Global Positioning System (GPS) and Geographical Information System (GIS) tools. Spatial variability analysis of nutrients is one of the key factors for precision agricultural management. To assess

the variability of soil nutrients, geostatistical methods can be used (Mueller et al., 2003). The spatial variability achieved through the analysis of the function of spatial covariance and also estimated the values for unsampled locations without bias and with minimum variance. Thus the study of spatial variability of soil micronutrients data promotes support for the rational management of soil with the objective of the sustainable agricultural environment.

MATERIALS AND METHODS

Salem district is bound on the North by Dharmapuri district, on the South by Namakkal and Erode districts, the Western Ghats in the West and Villupuram district in the East. The district is having North Latitude between $11^{\circ} 14'$ and $12^{\circ} 53'$ and East Longitude between $77^{\circ} 44'$ and $78^{\circ} 50'$. The geographical area of the district is 5, 20 and 134 ha. The agriculture sector provides the major source of income to the population of the district. Salem district has nine taluks viz., Attur, Mettur, Omalur, Sangagiri, Salem, Yercaud, Valapady, Gangavalli and Idappadi. The district comprises of twenty blocks viz., Salem, Veerapandi, Panamarathupatti, Ayodhiyapattinam, Valapady, Yercaud, Kolathur, Nangavalli, Mecheri, Omalur, Taramangalam, Kadaiyampatti, Attur, Peddanaickenpalayam, Talaivasal, Gangavalli, Sangagiri, Macdonalds Choultry, Idappadi and Konganapuram with 385 Panchayat villages.

Soil samples were collected @ 4 numbers per Panchayat village randomly at 0-15 cm depth by adopting the standard procedures of soil sample collection. Totally 1691 samples were collected and the Global Positioning System (GPS) readings (Latitude °N and Longitude °E) of each sampling site were recorded at the time of sample collection. Along with this, site performa for each site was also filled, which includes details about the crop stand in the soil sampling site, major crops cultivated in that locality, system of cultivation, fertilization practices and source of irrigation. The available Zn was extracted with DTPA (0.005M Diethylene Triamine Penta Acetic Acid + 0.1M Triethanolamine + 0.01 M CaCl_2) extractant adjusted to $\text{pH } 7.3 \pm 0.5$ using 1:1 dilute HCl at 1:2 ratio (Soil : DTPA-extractant) and the content was estimated using Atomic Absorption Spectrometer (Lindsay and Norvell, 1978). The available B status of the soil was estimated using hot water as extractant (Berger and Troug, 1946).

The soil samples were categorized into low, medium and high categories based on the critical limit of available Zn and B (Table 1). The deficiency per cent sample at each category was assessed for all elements at block level. Nutrient index values were calculated from the proportion of soils under low, medium and high available nutrient categories, as represented by

$$\text{NIV} = \frac{[(\text{PH} \times 3) + (\text{PM} \times 2) + (\text{PL} \times 1)]}{100}$$

Where,

NIV = the nutrient index value

PL, PM and PH are the percentage of soil samples falling in the category of low, medium and high nutrient status and given weight age of one, two and three respectively (Ramamurthy and Bajaj, 1969). The index values are rated in to various categories viz., very high (>2.67), high (2.33 to 2.67), adequate (2.00 to 2.33), marginal (1.67 to 2.00), low (1.33 to 1.67) and very low (<1.33) for fertility rating.

The Salem district map (1:50,000) was vectorised by using Raster to Vector software (R2V), and then exported into Arc-GIS software. Database on soil micronutrients and sulphur status of the study area was developed using Microsoft Excel package. The database was exported to Arc-GIS software. In the present investigation, linear directional

semivariogram are constructed for available Zn and B in spatial dependent models by plotting the semi-variance is a function of log between neighboring observations.

Table 1: Critical Limits for the Soil Samples Categorization into Different Fertility Classes

Element	Category		
	Low	Medium	High
Zinc (Zn)	< 1.2	1.2-1.8	> 1.8
Boron (B)	< 0.46	0.46 - 1.0	> 1.0

RESULTS AND DISCUSSIONS

The DTPA-Zn status of the soils ranged from 0.2 to 17.5 mg kg⁻¹ with a mean of 1.6 mg kg⁻¹ (Table 2). Most of the soils were found to be deficient in Zn status based on critical value of 1.2 mg kg⁻¹ with lower range starting from as low as 0.20 mg kg⁻¹ in the soils of Attur, Salem, Ayodhiyapattinam, Omalur and Idappadi blocks. The mean value showed that available Zn was the highest in Yercaud (4.3 mg kg⁻¹) followed by Salem and Kolathur blocks (2.2 mg kg⁻¹). The lowest mean available Zn content was observed in Konganapuram (0.9 mg kg⁻¹).

The per cent sample category for DTPA-Zn was classified under low, medium and high category based on critical limits. The results showed that 50.7, 23.6 and 25.7 per cent of total samples were under low, medium and high category respectively (Table 2). Out of the 20 blocks, the highest percentage of deficient samples was found in Konganapuram (77.5 %) block followed by Taramangalam (73.6%) and Idappadi (73.1 %) blocks. Lesser percentage of deficient samples was found in Yercaud block (2.9 %). The nutrient index value for Zn in the soils of Salem district ranged from 1.28 to 2.74 with a mean of 1.75 which indicated that the soils were very low in Zn status (Table 2). Among the blocks, Yercaud block registered the very high Zn status while very low fertility status was shown by Konganapuram with index values of 2.74 and 1.28 respectively. The low availability of Zn content in the investigated soils of some blocks might be due to the low OC in these blocks. The results of the present investigation are in conformity with those of Takkar *et al.* (1997) who envisaged that when the soils are low in organic matter and not supplemented by mineral fertilization they are prone to zinc deficiency. Based on nutrient index values fertility map for Zn was prepared using Arc GIS software (Figure 1).



Figure 1: Fertility Map for Available Zn

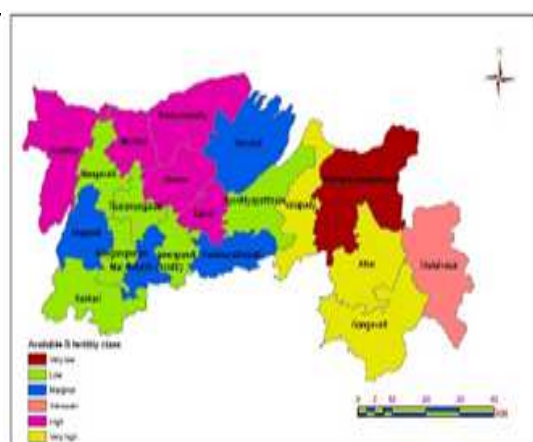


Figure 2: Fertility Map for Available B

Table 2: Range, Mean Values, Percent Sample Category, NIV and Fertility Rating of DTPA - Zn for all the Blocks in Salem District

Sl. No.	Name of the Blocks	No of Samples Collected	Range	Mean Value of DTPA Zn	Percent Sample Category			NIV	Fertility Rating
					Low	Medium	High		
1	Attur	80	0.20-5.6	1.4	57.5	21.3	21.2	1.64	Low
2	Gangavalli	72	0.34-7.6	1.4	56.9	20.8	22.3	1.65	Low
3	Peddanaickenpalayam	172	0.38-8.1	1.5	50.6	24.4	25.0	1.76	Marginal
4	Talaivasal	144	0.52-5.8	1.5	44.5	34.7	20.8	1.76	Marginal
5	Kolathur	60	0.51-11.3	2.2	28.3	30.0	41.7	2.13	Adequate
6	Mecheri	72	0.39-4.1	1.2	65.3	22.2	12.5	1.47	Low
7	Nangavalli	56	0.71-5.7	2.1	17.9	26.8	55.3	2.38	High
8	Kadaiyampatty	76	0.50-17.5	1.7	44.7	31.6	23.7	1.80	Marginal
9	Omalur	144	0.20-8.2	1.5	64.6	11.8	23.6	1.60	Low
10	Taramangalam	72	0.36-7.6	1.3	73.6	12.5	13.9	1.40	Low
11	Ayodhiyapattinam	128	0.20-7.8	1.7	38.3	32.8	28.9	1.91	Marginal
12	Panamarathupatti	88	0.39-5.7	1.5	52.3	19.3	28.4	1.76	Marginal
13	Salem	55	0.20-8.2	2.2	32.7	34.5	32.8	2.00	Marginal
14	Valapady	96	0.45-3.3	1.3	41.7	34.3	24.0	1.82	Marginal
15	Veerapandi	103	0.37-5.4	1.3	54.4	32.0	13.6	1.59	Low
16	Idappadi	52	0.20-6.0	1.1	73.1	13.5	13.4	1.40	Low
17	Konganapuram	40	0.27-3.2	0.9	77.5	17.5	5.0	1.28	Very low
18	Macdonalds Choultry	56	0.32-4.4	1.2	67.9	14.3	17.8	1.50	Low
19	Sangagiri	90	0.23-3.5	1.1	70.0	15.6	14.4	1.44	Low
20	Yercaud	35	1.13-9.4	4.3	2.9	20.0	77.1	2.74	Very high
District		1691	0.2-17.5	1.6	50.7	23.6	25.7	1.75	Marginal

Soil samples of Salem district were found to be low in HWS-B to an extent of 32.3 per cent while 35.1 and 32.6 per cent of samples were found to be medium and high category respectively (Table 3). Specifically higher B status was noticed in Attur (97.5 %), followed by Gangavalli (87.5 %) and Valapady block (76.0 %). Higher per cent of medium category samples were noticed in Panamarathupatti (69.3 %) and Yercaud (60.0 %) blocks. The samples from Attur, Gangavalli, Mecheri, Omalur and Valapady blocks did not show B deficiency and the highest value was observed in Peddanaickenpalayam (73.9 %) followed by Veerapandi (68.9 %).

Generally, the values for HWS-B ranged from 0.10 to 4.6 mg kg⁻¹ (Table 3). The highest available B content was registered in the soils of Kadaiyampatti (4.6 mg kg⁻¹) with a mean of 2.92 mg kg⁻¹ followed by Macdonalds Choultry block (4.4 mg kg⁻¹) while the lowest (0.10 mg kg⁻¹) was noticed in the soils of Peddanaickenpalayam, Nangavalli, Ayodhiyapattinam, Veerapandi, Idappadi, and Sangagiri blocks. Soil samples of Salem district were found to be low in HWS-B to an extent of 32.3 per cent while 35.1 and 32.6 per cent of samples were found to be medium and high category respectively (Table 3). Specifically higher B status was noticed in Attur (97.5 %), followed by Gangavalli (87.5 %) and Valapady block (76.0 %). The low availability of boron might be due to the adsorption of boron on clay minerals and fixation via ligand exchange which probably reduced their availability (Keren *et al.*, 1994). Gangavalli and Valapady blocks could be due to natural concentration of B in soils or continued use of irrigation water having high in soluble salts including B (Bradford *et al.*, 1996). Further regular addition of organic/green manures might have also contributed to the

higher B availability by adsorbing more in organic complex than in mineral constituents (Yermiyaho *et al.*, 1988; Gu and Lowe, 1990; Datta *et al.*, 2002; Nazif *et al.*, 2006).

Table 3: Range, Mean Values, Percent Sample Category, NIV and Fertility Rating of HWS B for all the Blocks in Salem District

Sl. No.	Name of the Blocks	No of Samples Collected	Range	Mean Value of HWS B	Percent Sample Category			NIV	Fertility Rating
					Low	Medium	high		
1	Attur	80	0.67-4.2	1.73	0	2.5	97.5	2.98	Very high
2	Gangavalli	72	0.74-2.0	1.31	0	12.5	87.5	2.85	Very high
3	Peddanaickenpalayam	172	0.10-2.1	0.37	73.9	22.6	3.5	1.29	Very low
4	Talaivasal	144	0.17-1.9	0.89	11.8	54.2	34.0	2.22	Adequate
5	Kolathur	60	0.35-2.4	1.13	3.3	40.0	56.7	2.53	High
6	Mecheri	72	0.65-1.6	0.99	0	59.7	40.3	2.40	High
7	Nangavalli	56	0.10-1.4	0.47	60.7	28.6	10.7	1.50	Low
8	Kadaiyampatty	76	0.2-4.6	2.92	6.6	34.2	59.2	2.53	High
9	Omalur	144	0.66-1.5	1.00	0	55.6	44.4	2.44	High
10	Taramangalam	72	0.14-1.3	0.44	65.3	31.9	2.8	1.38	Low
11	Ayodhiyapattinam	128	0.10-1.0	0.39	63.3	35.9	0.8	1.39	Low
12	Panamarathupatti	88	0.35-1.1	0.53	28.4	69.3	2.3	1.74	Marginal
13	Salem	55	0.13-2.4	0.95	12.7	34.5	52.8	2.40	High
14	Valapady	96	0.51-3.8	1.25	0	24.0	76.0	2.76	Very high
15	Veerapandi	103	0.10-1.5	0.38	68.9	27.2	3.9	1.35	Low
16	Idappadi	52	0.10-2.6	0.66	51.9	25.0	23.1	1.75	Marginal
17	Konganapuram	40	0.11-1.3	0.49	67.5	20.0	12.5	1.48	Low
18	Macdonalds Choultry	56	0.10-4.4	0.69	53.6	26.8	19.6	1.68	Marginal
19	Sangagiri	90	0.10-3.1	0.52	55.6	36.6	7.8	1.52	Low
20	Yercaud	35	0.11-1.8	0.75	22.9	60.0	17.1	1.94	Marginal
	District	1691	0.10-4.6	0.89	32.3	35.1	32.6	2.01	Adequate

The nutrient index value for available B ranged from 1.29 to 2.98 with fertility status of low to very high and the district overall status (2.01) was found to be adequate (Table 3). Among the blocks, very low B fertility status was registered for the Peddanaickenpalayam block whereas the fertility status was rated as low in Taramangalam, Ayodhiyapattinam, Veerapandi, Konganapuram and Sankari blocks of the district. The blocks viz., Yercaud, Macdonalds Choultry, Idappadi, and Panamarathupatti were rated as marginal fertility status where as Talaivasal block showed adequate B fertility status. The soil samples of Kolathur, Mecheri, Kadaiyampatti, Omalur and Salem blocks were rated under high fertility status while Valapady, Attur and Gangavalli blocks were rated under very high fertility status. Fertility map was prepared for B based on nutrient index values using Arc GIS software (Figure 3).

CONCLUSIONS

The wide spread deficiency of Zn in Salem district showed that Zn is the most important limiting factor for sustainable productivity and corrective measures and proper management practices are required to avoid increase in the magnitude of the problem. The findings of Shyempura and Seghal (1995) and Katyal and Datta (2004) also subscribe to this view. The status of Zn and B depicts that it may acquire the status of deficiency in future due to exploitation of the

nutrients by intensive farming. Hence care should be taken to maintain the levels of available Zn and B in the soil to overcome the increasing deficiency in near future. The use of organic manures or inorganic micronutrient fertilizers can be used to increase the micronutrient availability.

REFERENCES

1. Berger, K.C. and Truog, E. (1946) Boron availability in relation to soil reaction and organic matter content. *Soil Science Society of America Journal* **10**, 113-116.
2. Datta, S.P., Rattan, R.K., Suribabu, K. and Datta, S.C. (2002) Fractionation and colorimetric determination of boron in soils. *Journal of Plant Nutrition and Soil Science* **165**, 179-184.
3. Gu, B. and Lowe, L.E. (1990) Studies on the adsorption of boron on humic acid. *Canadian Journal of Soil Science* **70**, 305-311.
4. Katyal, J.C. and Datta, S.P. (2004) Role of micronutrients in ensuring the optimum use of macronutrients. Paper presented at IFA International symposium on micronutrients, held at New Delhi, India during February 23-25.
5. Keren, R., Grossl, P.R. and Sparks, D.L. (1994) Equilibrium and kinetics of borate adsorption – desorption on pyrophyllite in aqueous suspensions. *Soil Science Society of America Journal* **58**, 1116-1122.
6. Lindsay, W.L. and Norvell, W.A. (1978) Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal* **42**, 421-428.
7. Mueller, T.G., Hartsock, N.J., Stombaugh, T.S., Shearer, S.A., Cornelius, P.L. and Barnhise, R.I. (2003) Soil electrical conductivity map variability in limestone soil overlain by loess. *Agronomy Journal* **95**, 496-507.
8. Nazif, W., Perveen, S. and Salem, I. (2006) Status of micronutrients in soils of district Bhimber (Azad Jammu and Kashmir). *Journal of Agricultural and Biological Science* **1(2)**, 35-40.
9. Ramamoorthy, B. and Bajaj, J.C. (1969) Available N, P and K status of Indian soils. *Fertilizers News* **14**, 24-26.
10. Sharma, J.C. and Chaudhary, K. (2007) Vertical distribution of micronutrient cations in relation to soil characteristics in lower Shiwaliks of Solan district in north-west Himalayas. *Journal of the Indian Society of Soil Science* **55**, 40-44.
11. Shyampura, R.L. and Sehgal, J. (1995) Soils of Rajasthan for optimizing land use. NBSS public, 51 (Soil of India series) NBSS & LUP Nagpur 76 + 6 sheets of soil map.
12. Takkar, P.N., Nayyar, V.K., Bansal, R.L., Dwivedi, R.S. and Manna, M.S. (1997) Annual progress report of ICAR co-ordinated micronutrient scheme 1996-97. Punjab Agricultural University, Ludhiana.
13. Yermiyaho, U., Keren, R. and Chen, Y. (1988) Boron sorption on composted organic matter. *Soil Science Society of America Journal* **52**, 1309-1313.